NASA-CR-202066

A Study of Low Luminosity, Low Temperature X-ray Clusters

NASA Grant NAG5-2097

Final Report

For the Period 15 September 1992 through 14 September 1994

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August 1996

Prepared for:

National Aeronautics and Space Administration
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The Smithsonian Astrophysical Observatory is a member of the Harvard-Smithsonian Center for Astrophysics

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Final Report
Low Luminosity, Low Temperature Clusters

1 Introduction

Clusters of galaxies with low x-ray luminosity and low gas temperatures represent a class of clusters which can provide unique insights into the relationships between the diffuse intracluster gas and the galaxies within the cluster. In contrast to rich clusters which contain a bright intracluster medium, in these low luminosity clusters, x-ray emission from both individual cluster member galaxies and from the diffuse intracluster gas is detectable. The Einstein observations of this class of clusters only served to indicate their interesting potential but lacked adequate spatial resolution and the low internal detector background needed to study these faint, low surface brightness systems.

2 Completed Analysis

We (Finoguenov et al. 1996) have carried out a detailed analysis of the ROSAT data for A194 and a less complete analysis for A76 because of its lower flux. For A194, Figure 1 shows the wavelet deconvolved image superposed on the digitized optical sky survey image. The wavelet transform smoothing is a new technique that smoothes without degrading the resolution of the image and is in this sense similar to adaptive smoothing (see Vikhlinin et al. 1996). A194 is rather unique since the emission from numerous galaxies can be seen along with that from the hot intracluster medium. In addition to the galaxies, additional serendipitous point sources are seen.

We have defined a set of energy bands which serve to characterize different properties of the emission from the hot gas seen in the galaxies and the ICM. Using the standard notation of Snowden et al. (1994), we found that the ratio (R67–R45)/(R67+R45) provides a robust estimate of the gas temperature. In Figure 2 we show the derived temperature map (grey scale), overlaid on the X-ray surface brightness contours (R47; broader band image). The temperature scale is such that darker tones indicate cooler regions and lighter tones indicate hotter gas. Corresponding to decreasing surface brightness contours, the uncertainties on the derived temperature map increase at fainter fluxes (away from the cluster center). Hence, the changes in greyscale beyond the outer contour of surface brightness are not statistically significant. The cooler emission associated with the bright galaxy near the cluster center is apparent. Small temperature changes are seen, within the outer surface brightness contour, but for the most part, the cluster core is approximately isothermal.

We have also shown that the heavy element (Fe abundance) could be approximately mapped using the ratio (R2-R67)/(R2+R67) assuming that the hydrogen column density is approximately constant. We have used this ratio to derive the "abundance" map for the cluster. No strong changes in abundance are seen. We plan to compare the ROSAT and ASCA abundances since there is some question as to how well ROSAT can determine the heavy element abundances with its relatively narrow energy band. Hence, while the ratio (R2-R67)/(R2+R67) formally yields a measure of the heavy element abundance, we are not certain that this measure is accurate.

For A76, we have only begun the analysis with the wavelet transform analysis and the ratios of the energy bands. In Figure 3, we show the smoothed contour map of the ROSAT image. The number of counts in the image is much smaller than for A194 and hence the possible analyses will be significantly limited. We also show the wavelet smoothed image in Figure 4. While the amount of detailed information is less than for A194, A76 does show a remarkable amount of substructure.

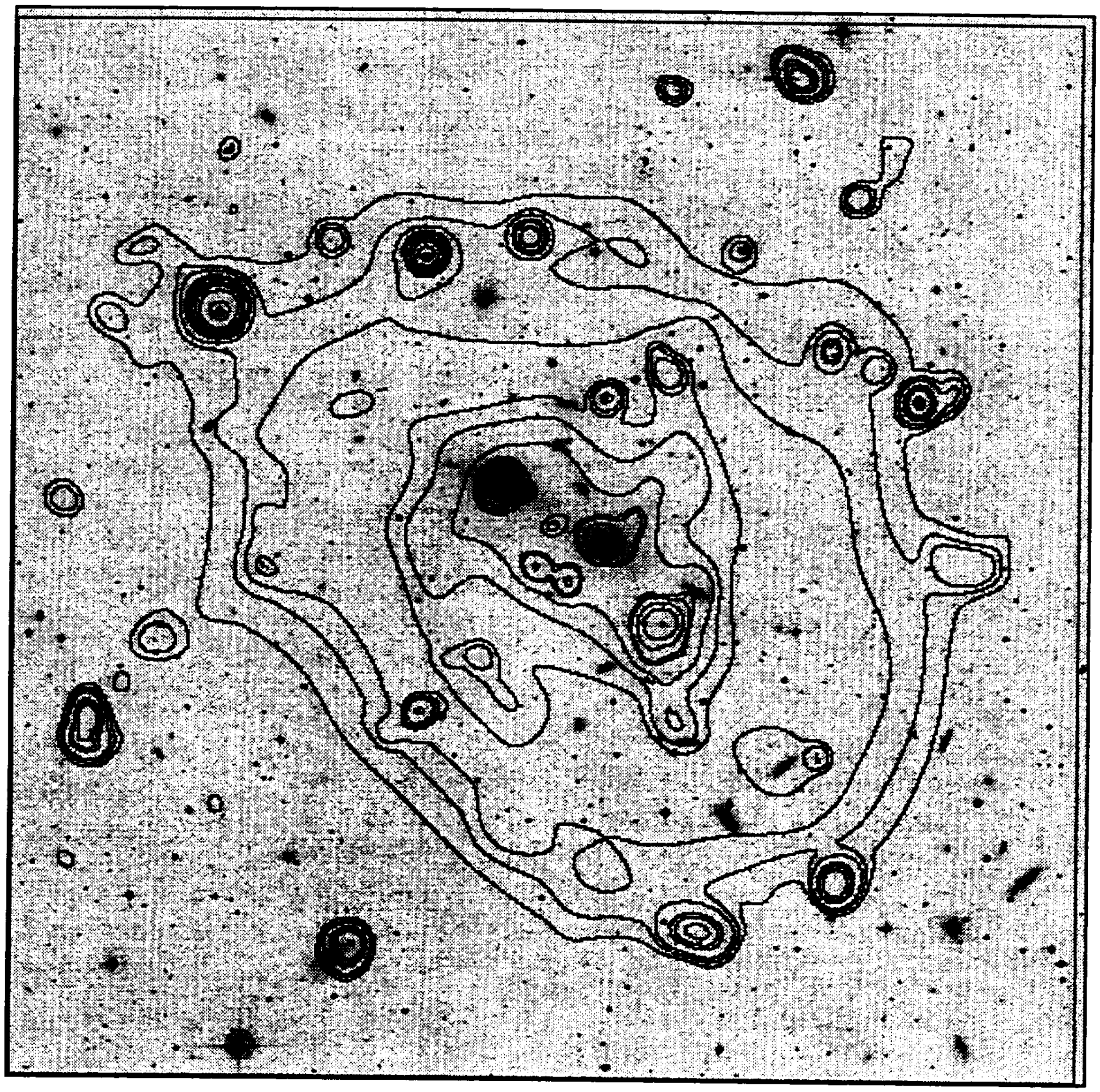
3 References

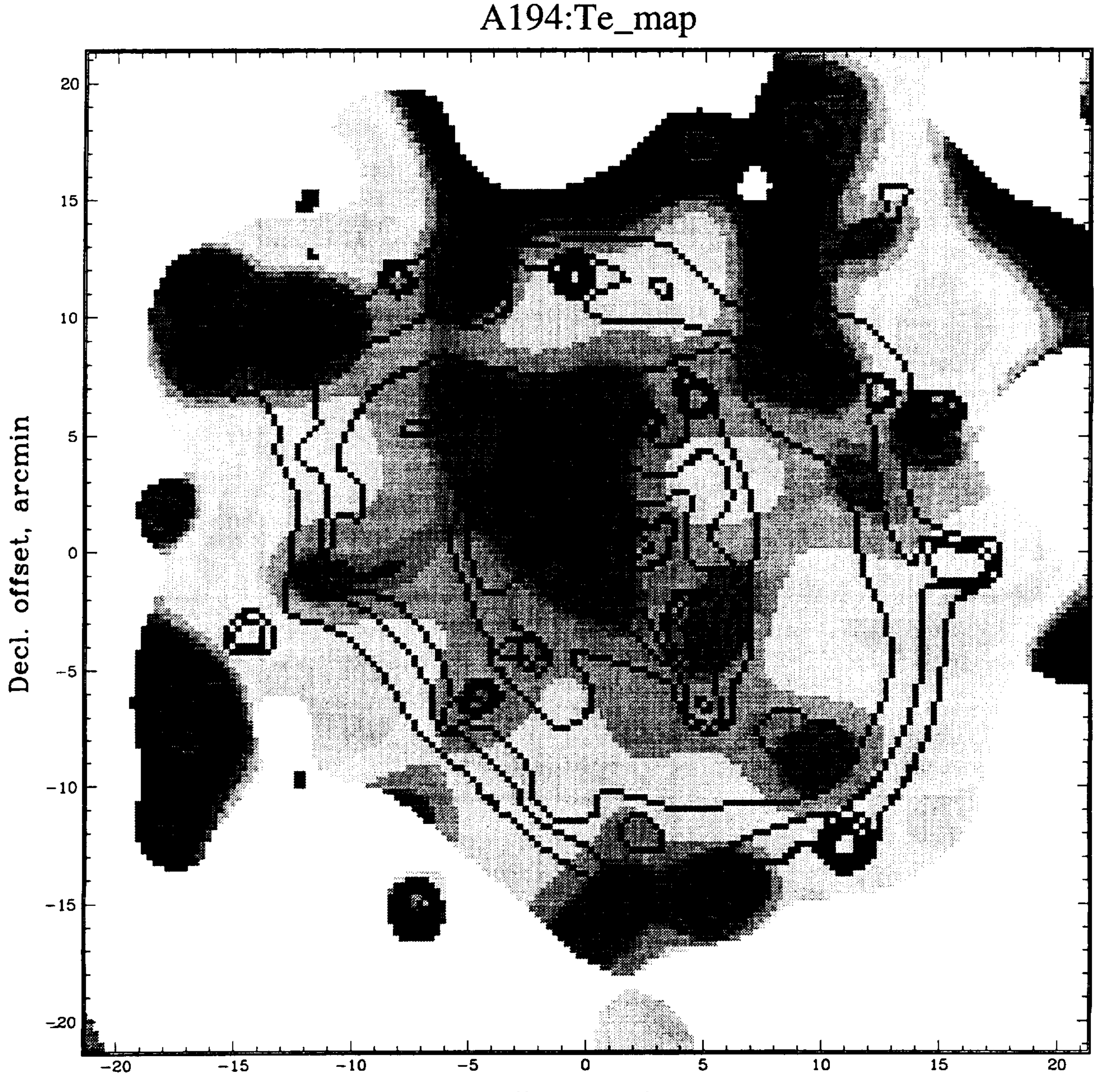
Finoguenov, A. et al. 1996, in preparation.

Snowden S.L., McCammon D., Burrows D.N. and Mendenhall J.A. 1994, ApJ, 424, 714

Vikhlinin, A., Forman, W. and Jones, C. 1996, Ap. J. Letters, in press

A194:DSS_ROSAT




A194:Te_map
Decl. offset, arcmin
R.A. offset, arcmin
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-10
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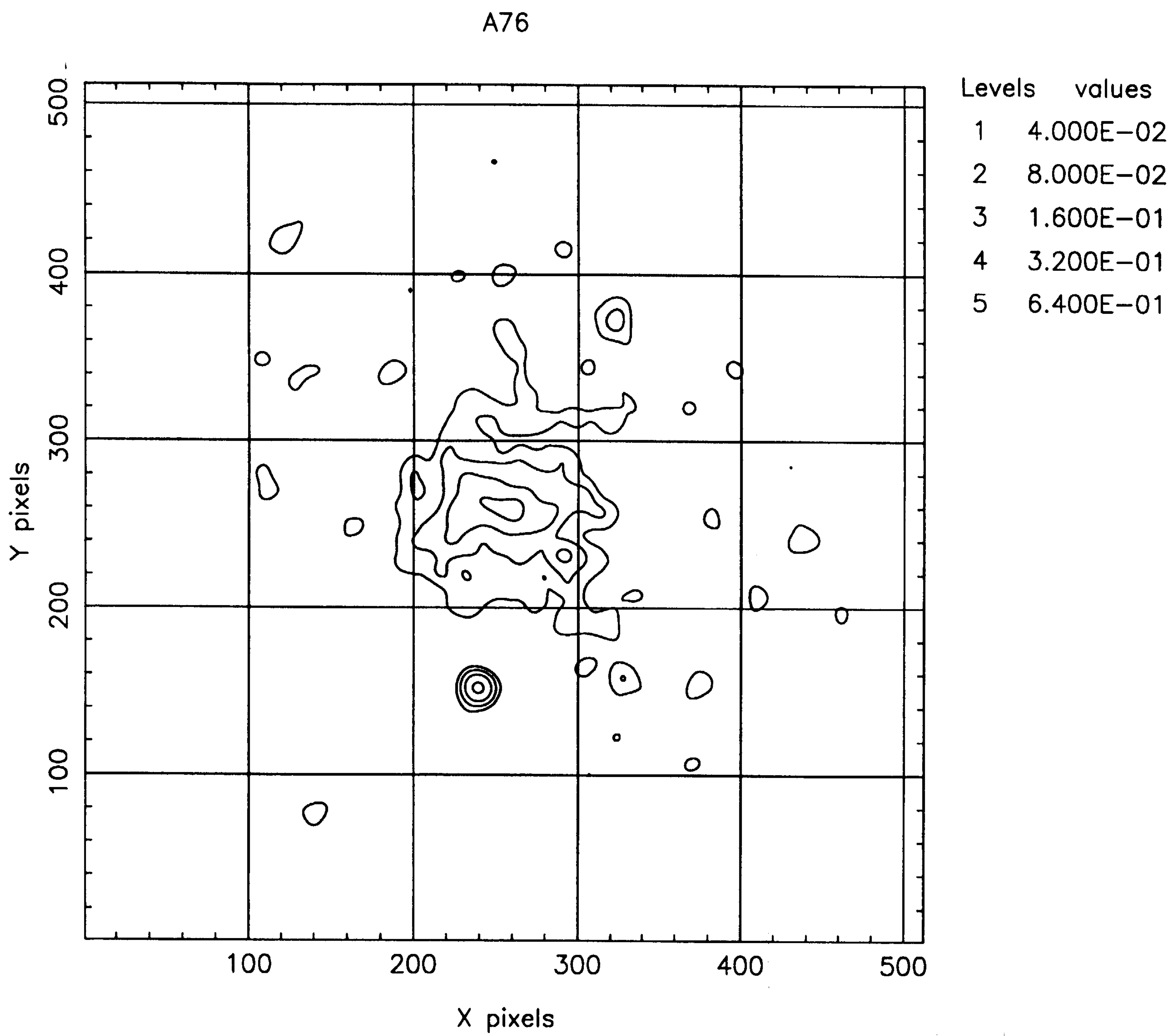
0
5
10
15
20


A76
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2 8.000E−02
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4 3.200E−01
5 6.400E−01
Y pixels
X pixels
100
200
300
400
500